But although these experiments seem to lead to this conclusion, more extended researches with other gases of the same nature, using the same precautions, will have to be made, before the real form of the curve can be ascertained.

This investigation has been carried out in the Laboratory of the Royal Institution.

X. "On an Arrangement of the Electric Arc for the Study of the Radiation of Vapours, together with Preliminary Results." By G. D. LIVEING, M.A., F.R.S., Professor of Chemistry, and J. DEWAR, M.A., F.R.S., Jacksonian Professor, University of Cambridge. Received June 8, 1882.

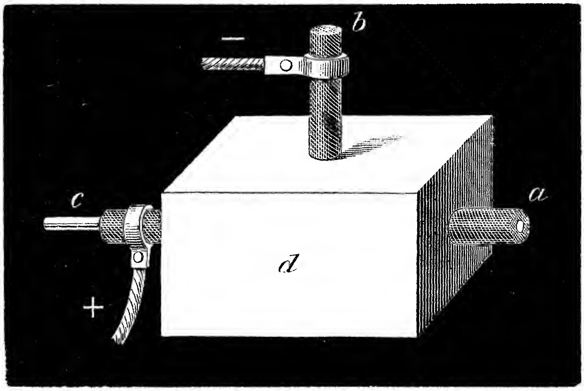
In previous papers* we have described various devices for facilitating the study of the reversal of the lines of metallic vapour. The first series of observations were made by examining the spectrum of the interior of iron or porcelain tubes filled with vapour and heated to the highest temperature of a coke furnace, the subsequent series being eye or photographic records of the radiation of the electric arc surrounded by metallic vapour in the middle of blocks or tubes of lime or magnesia.

By inclosing the arc in a crucible of lime or magnesia we have found its steadiness very greatly increased, and the mass of metallic vapour which can be maintained at a temperature approaching to that of the arc much enlarged, but it cannot be said that that temperature is at all under control, and the walls of the crucible are almost always cooler than the contents. By the arrangement we have now to describe we are able to make observations through a long range of temperature, as the temperature rises and as it falls, and so to trace the influence of temperature in many cases in which the extent of that influence was before doubtful. The temperature attainable is doubtless far below that of the arc, but still it is quite sufficient to maintain iron and aluminium in the state of vapour, and show the reversal of the lines of these elements with singular sharpness. The temperature of the interior is sufficiently high to transform the diamond into coke, even in a current of hydrogen, and the result may be taken as proving that the temperature is above that of the oxyhydrogen flame.

The apparatus employed is thus constructed: A rod of carbon, a in the figure, 15 millims. in diameter, perforated down its axis with a cylindrical hole 4 millims. in diameter, is passed through a hole in a lime

* "Proc. Roy. Soc.," "On the Reversal of the Lines of Metallic Vapours," vols. 28, 29, 32.

block *d*, and is connected by means of a copper clip with the positive electrode of a Siemens dynamo-electric machine; another carbon rod *b*, unperforated, is passed into the lime block through a second hole



at right angles to the first, so that the end of the rod *b* meets the rod *a* in the middle of the block of lime. The rod *b* is connected with the negative electrode of the dynamo machine, and after contact is made between the two carbons is raised a little so that the arc discharge continues between the two carbon rods within the block of lime or magnesia. In this way the outside of the rod or tube, *a*, becomes intensely heated, the heat is retained by the jacket of lime, and the interior of the tube gradually rises in the central part to a very high temperature. By stopping the arc it can be made to pass through the same stages of temperature in the inverse order. Observations are made by looking down the perforation. When the light issuing from the tube is projected by a lens on to the slit of a spectroscope, the heated walls of the tube give at top and bottom a continuous spectrum, against which various metallic lines are seen reversed, while in the central part, when the tube is open at the farther end, the spectrum is discontinuous, and the metallic lines seen reversed against the walls at top and bottom, appear as bright lines.

By passing a small rod of carbon *c* into the perforation from the farther end, a luminous background can be obtained all across the field, and then, as the walls of the tube are hotter than the metallic vapours between them and the eye, the metallic lines are only seen reversed. A very slight alteration in the position of the carbon rod makes the lines disappear, or reappear, or show reversal, and as the core is adjusted by eye observation before photographs are taken, all the conditions of the experiments are thoroughly known and are

under easy control. We have taken photographs of the violet and lower part of the ultra-violet spectrum given by the tube at successive intervals while the temperature was rising, and noted the following results. When commercial carbons were used the first lines to be seen as the temperature rose were the potassium lines, wave-length 4044–6, next the two aluminium lines between H and K became conspicuous, then the manganese triplet about wave-length 4034, and the calcium line, wave-length 4226, then the calcium lines near M and an iron line, probably M, between them, and then gradually a multitude of lines which seem to be all the conspicuous iron lines between O and *h*. At this stage, when the small rod *c* is used to give a background, the bright continuous spectrum is crossed by a multitude of sharp dark lines, vividly recalling the general appearance of the solar spectrum. In the higher region the continuous spectrum extends beyond the solar spectrum, and the magnesium line, wave-length 2852, is a diffuse dark band, while all the strong iron lines about T, and the aluminium pair near S, are seen as dark lines. The behaviour of the calcium lines H and K is peculiar. These lines are often absent altogether, when the line wave-length 4226 and the two near M are well seen, and when the two aluminium lines between them and many of the iron lines are sharply reversed. Even the introduction of a small quantity of metallic calcium or calcium chloride into the tube did not bring them out reversed. They were only seen as bright lines, not very strong, when the small rod *c* was removed.

In some of the photographs H is visible as a bright line without K. We have formerly observed that K shows reversal in the electric arc spectrum taken in a lime crucible on the addition of aluminium, when H remains bright, and such a condition as that shown by the hollow carbon tube where H is present without K, might legitimately have been predicted. The lithium lines at 4603 and 4131 are often bright when many other lines in the neighbourhood are reversed, and must, therefore, be regarded as relatively difficult of reversal. As a rule the lines less refrangible than 4226 are balanced as to their emissive and absorptive power, and, therefore, disappear, while the more refrangible are reversed. The cyanogen group at 3883 remain bright when the iron lines on either side are reversed; they often, however, disappear on the continuous spectrum. Many lines about P and Q of the solar spectrum are reversed. The cyanogen band above K is generally to be found in the photographs of the spectrum when only air is in the tube. It is then very faint, and is the only cyanogen group visible. If ammonia is passed into the tube the fine set above K, the N group, and, although less plainly marked, the set at 4218, appear. In one plate the three lines at 4380 and the group of seven at 4600 appear along with the blue hydrocarbon set. It is well

known that ammonia reacts on carbon at a white heat, producing cyanide of ammonium and hydrogen, so that the genesis of the cyanogen spectrum under the present conditions is a crucial test of the validity of our former observations on this subject, which are, however, in marked disagreement with the results obtained by Mr. Lockyer, in his review of the same field of investigation.

Both the indium lines 4101 and 4509 are persistently reversed, together with several lead lines. Tin gives flutings in highly refrangible portions of the spectrum, and silver gives a fine fluted-looking spectrum in the blue. Chloride of calcium gives a striking set of six or seven bands between L and M, which may be seen both bright and reversed.

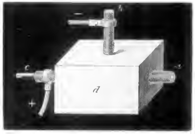
When the small rod *c* is removed, it is easy at any moment to sweep out the vapours in the tube by blowing through it; it is equally easy to pass in reducing or other gases. Ammonia introduced seems to facilitate the appearance of reversed lines. On passing this gas through a tube containing magnesia, the set of lines just below *b*, which we have always found to be associated with the presence of magnesium and hydrogen, and is most probably due to some compound, instantly appear.

The above is a brief abstract of the few observations we have been able to make as a preliminary to a more thorough research, and we feel warranted in thinking that the method promises to solve some intricate spectroscopic problems. When we can command several electric arcs to heat a considerable length of carbon tube, and are enabled to examine the radiation of a powerful arc passing through vapours in the tube, valuable results may be anticipated.

XI. "On the Ultra-violet Spectra of the Elements. Part I. Iron." By G. D. Liveing, M.A., F.R.S., Professor of Chemistry, and J. Dewar, M.A., F.R.S., Jacksonian Professor, University of Cambridge. Received June 8, 1882.

(Abstract.)

By means of photographs taken with a Rutherford grating of 17,296 lines to the inch, the authors have determined the wave-lengths of ninety-one of the most prominent lines in the spark spectrum of iron between wave-lengths 2948, the termination of Cornu's map of the solar spectrum, and 2327, and also of fourteen of the strongest lines in the spark spectrum of copper beyond that up to the wave-length 2135. Using these lines as lines of reference they have, from photographs taken with calcite prisms, deduced the wave-lengths of 584 more lines in the arc and spark spectra of iron within those



b
c
d
a